THE CONODONT FAUNA OF THE UPPER ONE HUNDRED METERS OF THE CHAGRIN SHALE IN EASTERN LAKE COUNTY, OHIO

A Thesis

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Geology

by

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ABSTRACT

A stratigraphic section 100 m. thick of the uppermost Chagrin Shale was compiled for its exposures in the valley of Paine Creek, in Lake County, Ohio. It was possible to do this using siltstone "key beds." This section was sampled for conodonts. Conodonts were found to be scarce in the upper part of this section, and more plentiful 70 m. down in the section. The form genus Palmatolepis was not found, but the form genus Polygnathus was found in 6 samples, and included 4 or 5 species, including P. semicostatus and P. delicatulus. Simple cones were recovered from 7 samples, and what may be a new form of Pelekysgnathus was recovered near the top of the section. The Famennian age of the upper 100 m. was confirmed. Evidence was presented supporting the proposed shallow-water marine environment of deposition for the Chagrin Shale.

INTRODUCTION

The purpose of this study is to examine the conodont fauna of the upper (100 m.) of the Chagrin Shale where it is exposed in the drainage of Paine Creek in Lake County, in Northeastern Ohio.

Prosser (1912) considered the Chagrin Shale the gray shale facies of the Huron Shale and the Cleveland Shale, and he considered it as Late Devonian in age. Both of these ideas remain valid according to Oliver et al. (1967), Schwietering (1970), and many others. The Chagrin Shale is now thought to be Famennian in age, within the Late Devonian (Oliver, et al., 1967). This is based on zonation using brachiopods, done largely by Cooper et al. (1942); and it is based on lithologic correlations with other formations to the east of known age (Oliver, et al., 1967 and Schwietering, 1970). This study begins the examination of conodonts found in the Chagrin Shale.

Upper Devonian conodont faunas have been intensively studied. Ziegler (1962) zoned the Upper Devonian of Western Europe and correlated this with the standard European goniatite zonation. Collinson et al. (1962) zoned the Upper Mississippi Valley. More recent work has been summarized by Ziegler et al. (1975).

METHODS

The upper 100 m. of the Chagrin Shale is not all exposed in one outcrop, and must be pieced together from several exposures. In order to determine the positions of the samples with respect to the top of the formation, I measured 8 stratigraphic sections. I had to assume that the siltstone beds were persistent enough to be used for lithologic correlation between measured sections.

The samples were washed off in the laboratory. They were then heated for two hours at 192°C. After 30 minutes of cooling off in the open air, they were soaked in kerosene for two days. After this the kerosene was returned to its container, and water was added to the shale. Two days later the samples were washed onto 100- and 20-mesh U.S. Standard sieves. These recovered conodonts, quarts grains, and shale particles. The shale particles were removed with a magnetic separator.

MEASURED SECTION AND COLLECTION LOCALITIES

The locality number corresponds with the number on the 7.5-minute quadrangle maps on the following pages.

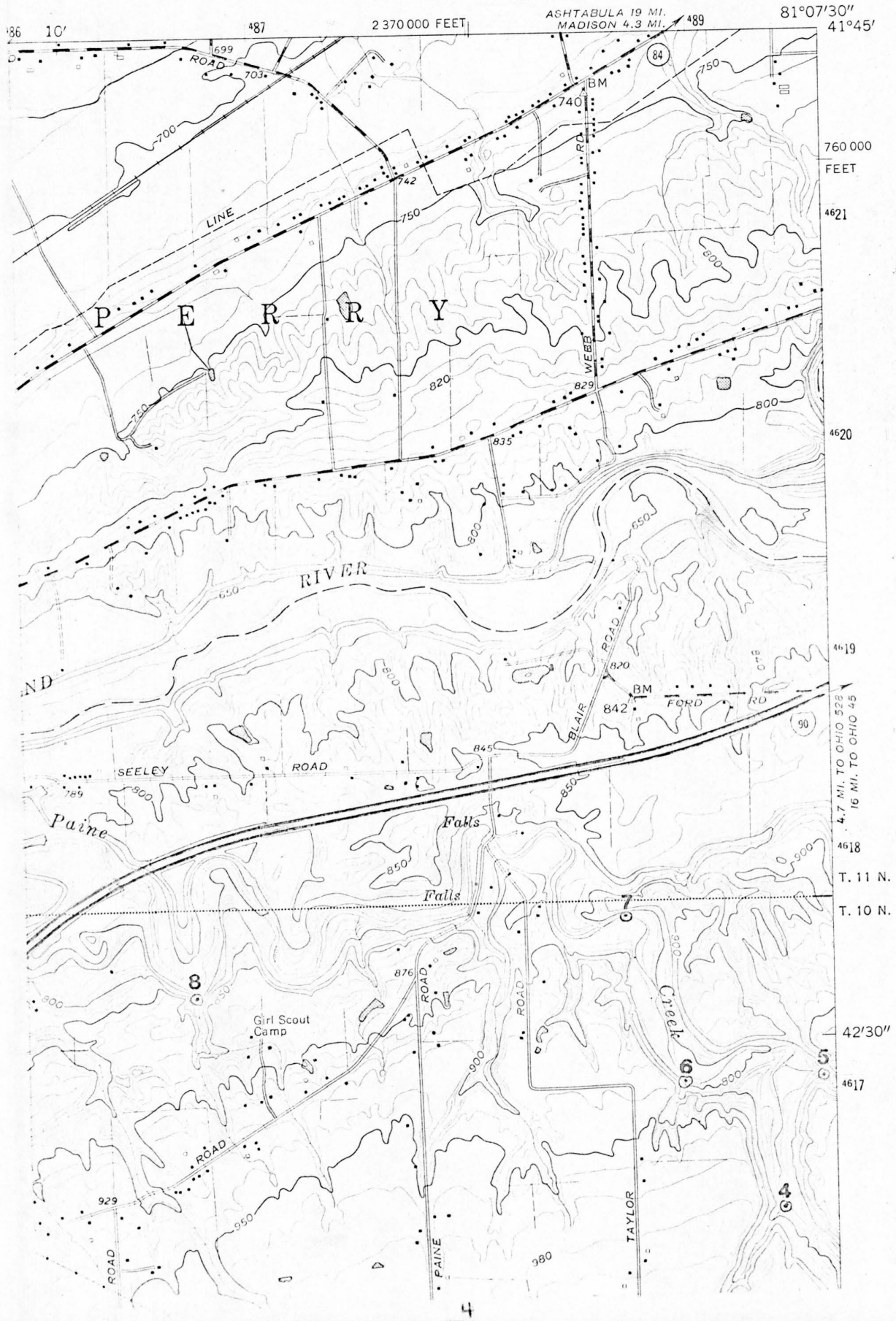
LOCALITY 1 - This is an exposure above Leroy Center Road, east of the bridge crossing Paine Creek. This section was measured straight up from the point on the map, because slumping has occured above the higher part of the road.

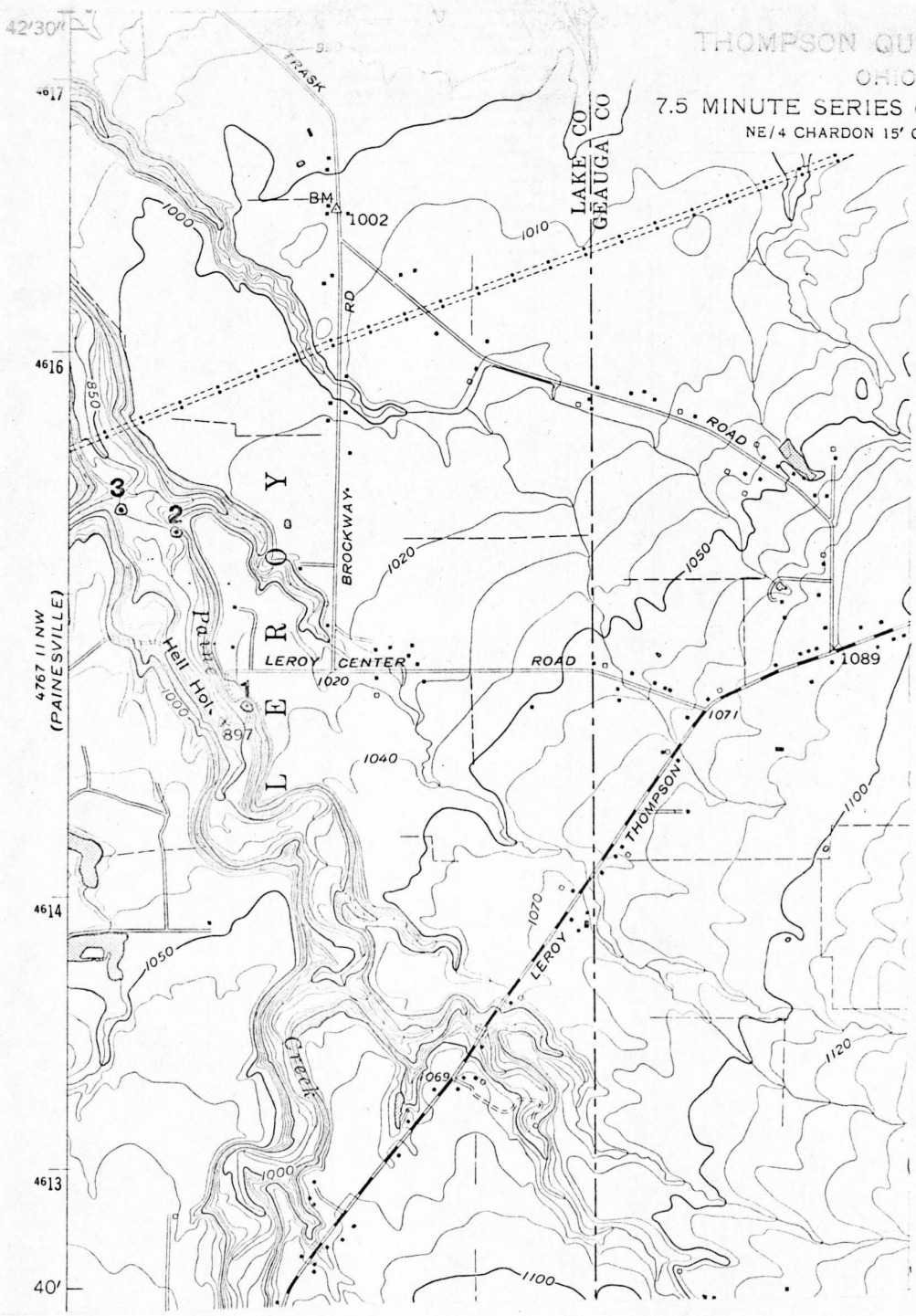
PAINESVILLE QUADRANGLE

OHIO

7.5 MINUTE SERIES (TOPOGRAPHIC)

NW/4 CHARDON 15' QUADRANGLE





THOMPSON QUADRANGLE

OHIO

7.5 MINUTE SERIES (TOPOGRAPHIC)

NE/4 CHARDON 15' QUADRANGLE

SCALE 1:24000

1 0 1 MILE

1000 0 1000 2000 3000 4000 5000 6000 7000 FEET

1 .5 0 1 KILOMETER

CONTOUR INTERVAL 10 FEET

DATUM IS MEAN SEA LEVEL

QUADRANGLE LOCATION

THIS MAP COMPLIES WITH NATIONAL MAP ACCURACY STANDARDS

FOR SALE BY U. S. GEOLOGICAL SURVEY, WASHINGTON, D. C. 20242

A FOLDER DESCRIBING TOPOGRAPHIC MAPS AND SYMBOLS IS AVAILABLE ON REQUEST

Samples 1-11 were collected here.

LOCALITY 2 - This exposure is a cliff on the east bank of the river, 0.73 km. north of the Leroy Center Road bridge. Samples 12 and 13 were collected here. The exposure is measured from creek level (low flow) at the north end of the cliff.

LOCALITY 3 - This exposure is a 7.2 m. high bank on the west side of the creek, 0.25 km. WNW of Locality 2, plus 1.6 m. of Chagrin Shale 40 m. downstream, which is added to the bottom of the 7.2 m. Sample 14 was collected from this interval.

LOCALITY 4 - This exposure is on a tributary into the creek, on the west side of the creek, 0.7 km. east of the word "Taylor" on the Painesville quadrangle. It was measured from creek level (low flow) on up the ravine. No samples were collected here.

LOCALITY 5 - This exposure is a falls and a steep bank on a tributary of Paine Creek, 0.63 km. NNE of Locality 6. No samples were collected here.

LOCALITY 6 - This exposure is on a tributary into the creek, on the west side of the creek, 0.64 km. west of Locality 5, measured from creek level on up into the south branch of the tributary. Sample 15 was collected at creek level.

LOCALITY 7 - This exposure is a cliff on the north side of the creek, 0.84 km. slightly west of north from Locality 6. The section was measured from creek level at the east end of the cliff. Samples 16 and 17 were collected here.

tributary, and then continues up the first tributary of the tributary on the north side.

LITHOLOGY

There are three basic types of siltstone, and they are unevenly distributed in the total section. Two types of siltstone (or very fine-grained sandstone) occur in the upper 58 m. of the section. The more resistant of the two is characterized by much horizontal and vertical burrowing, massive or poorly-developed stratification, sparse brachiopods, sharp upper and lower boundaries (the lower of which rests irregularly on the underlying shale), and in some cases by cementation by carbonate of variable composition. This type of siltstone is very resistant to weathering, and the key beds used for correlation are of this type. The other type of siltstone is less resistant, may lack sharp boundaries, has more clay-sized or fine silt-sized particles, and does not seem to be cemented by a carbonate cement. This type of siltstone is found throughout the section. The third type of siltstone is found in the lower 27 meters of the section. It is resistant to weathering, shows no evidence of burrowing, has fine light and dark gray laminations, splits easily along bedding planes, contains coalified plant remains, has resting fossils of elongate, many-legged arthropods, and may lack

sharp boundaries.

The shale is generally sandier and better cemented in the upper 60 m. of the section. It is almost always a light bluish-gray in color. Occasionally it has a dark gray or reddish tinge.

Continuous beds, lenses, and flat concretions characterized by the presence of siderite (which weathers to an iron oxide coating) are present throughout the section, but are more plentiful in the lower part. An undeformed specimen of the brachiopod genus Cyrtospirifer in a continuous bed may indicate an authigenic origin of some sort of carbonate. Acetic acid reacts very weakly with these rocks. The lenses sometimes take the form of fillings of ripple marks. These can have casts of trace fossil Bifungites, brachiopods, and casts of small crinoids on their lower surface.

FAUNA, CORRELATIONS, AND PALEOECOLOGY

Table 1 in the appendix summarizes the data from the samples.

The fauna was found to be sparsely represented in all of the samples except samples 3, 16, and 17. This may reflect rapid sedimentation, unfavorable preservation conditions, or unfavorable living conditions for the conodont-bearing animals.

Of the conodont elements in my collection, the form

genera Polygnathus and Spathognathodus are represented in 6 and 8 samples, respectively. Simple cones are present in 7 samples. Druce (1972) associates this sort of fauna (in combination with the absence of Palmatolepis, a deep water faunal element) with a shallow marine environment. Pelekysgnathus, also considered characteristic of shallow water faunas (Druce, 1972, Seddon, 1971), may be present in samples 3 and 4 near the top of the section. Druce (1972) and Seddon (1970) also consider Icriodus a shallow water genus. Only one specimen of Icriodus (from sample 4) was found. Druce (1972) reports that a fauna described by Mound (1968) from the Wabamun Group of Alberta contained simple polygnathids, cones, bars and blades, Pelekysgnathus, and Spathognathodus, while Palmatolepis and Icriodus were missing.

Flessa (1973) and Szmuc (1970) proposed that the Chagrin Shale was deposited in a shallow marine environment. Flessa (1973) came to this conclusion from studying the brachiopod fauna. Szmuc (1970) considers ripple marks, cross laminations, brachiopods (esp. Lingula), and the trace fossil Rusophycus as evidence for a shallow water environment. In my investigations, I did not find Rusophycus present in the sections exposed along Paine Creek. However, vertical burrows are common in the siltstones and fine-grained sandstones of the upper 58 m. of the section. The brachiopod genera Lingula, Orbiculoidea, and Camarotoechia were found

where sample 12 was collected, and these genera are often associated with shallow water environments.

Some of the specimens of the form genus Polygnathus belong to the species Polygnathus semicostatus. Four specimens from sample 16, 3 specimens from sample 17, and one specimen from sample 18 belong to a distinct variety of P. semicostatus. One specimen each from samples 3 and 12 contain what may be another variety of P. semicostatus. This latter variety differs from the older variety in having less distinct transverse ridges on the posterior third of the oral surface, and in having the carina level with the rim, while the older variety has the carina elevated above the rim in the anterior half of the oral surface. The two specimens from samples 3 and 12 are referred to as Polygnathus cf. P. semicostatus. According to Ziegler and others (1975), the age and range of the species is Lower rhomboidea- to Lower costatus- Zone in the Famennian.

From sample 16 came a single specimen of Polygnathus delicatulus. Ziegler and others (1975) give the age and range of this species as being Upper styriacus- Zone to lower part of costatus- Zone in the Famennian. This indicates that sample 16 was probably deposited within the range of Upper styriacus- Zone to Lower costatus- Zone, while sample 18 would have been deposited within the range of Lower rhomboidea- to Lower costatus- Zone.

The specimens found in samples 3 and 4 make the top of the section more uncertain with respect to age and range.

Seven simple cones: 4 oistodiform ones and 3 drepanodiform ones, occur in sample 3 along with what appear to be 3 broken I elements of the genus Pelekysgnathus. These may all belong to the same species. According to Druce (1972), the conodont-bearing animals which bore simple cones were extinct by the end of the Famennian. These cones did not show signs of being reworked. Ziegler and others (1975) consider the youngest Pelekysgnathus-bearing animals to be Famennian. In addition, Polygnathus cf. P. semicostatus should be a Famennian species.

One I element of Icriodus was recovered from sample 4. Ziegler and other (1975) report that Icriodus dies out in the Famennian.

Two or three unidentified form species of Polygnathus are present in the fauna. Sample 17 yielded one specimen each of P. sp. B and P. sp. C. P. sp. C is very small and is probably an immature specimen. It may be a young P. semicostatus, as this is also present and two transverse ridges are present on the posterior oral surface. P. sp. B is a large, well-preserved specimen, and may be useful for correlation if it can be identified.

Polygnathus sp. A was recovered from sample 3. It strongly resembles P. sp. B Thomas, 1949. Thomas listed the occurrence of this species as English River Siltstone and Prospect Hill Siltstone, all localities.

SUMMARY AND CONCLUSIONS

Current hypotheses that the Chagrin Shale was deposited under shallow marine conditions are supported by the conodont fauna. This fauna is sparse in the upper part of the formation, but appears to be much richer about 70 m. below in the section. This richer part of the fauna includes the form species Polygnathus semicostatus and P. delicatulus, confirming the Famennian age of this part of the formation. Near the top of the formation, Polygnathus cf. P. semicostatus, a possible Pelekysgnathus assemblage (2 types of simple cones and 3 broken I elements), plus one I element of Icriodus confirm the Famennian age of this uppermost part of the formation.

SYSTEMATIC PALEONTOLOGY

Genus ICRIODUS Branson & Mehl, 1934

Type species Icriodus expansus Branson & Mehl, 1938

Icriodus sp.

Pl. 3, figs. 1, 2

Description - One I element is present. All of the oral surface is covered with silt-sized quartz grains, except the smooth, tapered posterior and the anterior cusp. However, it is evident from lateral and oblique views that there are at least 2, and could possibly be 3 longitudinal rows of denticles on the oral surface. The most posterior

set of denticles bulges out laterally. The anterior cusp is proclined and laterally compressed. The conodont is moderately arched in the lateral view.

In the lateral view, the basal filling can be seen as dark brown material extending down a uniform distance along the entire length of the lower margin. In the aboral view it is seen to consist of a basal groove set in a keel; a large pit filled with silt particles, possibly a separate groove anterior of the pit, and a flat surface anterior of this groove. The basal groove set in the keel is present in the posterior 2/3 of the basal filling. It bifurcates where the pit begins, and becomes two separate grooves. These two grooves run off of the margin of the pit near its anterior end. After this, the basal filling that surrounds the pit has some flat topography with several bumps, except for what appears to be a silt-filled groove directly anterior of the pit. It is thin and runs parallel to the pit margin. The pit is bulb-shaped and widest near its posterior end.

Remarks - This specimen cannot be identified to species when the oral surface is covered with silt grains. However, it does seem to have some distinctive features, like the smooth posterior end, the exposed cusp, and the slightly flared denticles near the posterior end. It could be a new form of Pelekysgnathus, with several denticle rows. The occurrence of the arching, the smooth posterior, and the cusp would agree well with this.

Occurrence - One specimen was recovered from sample 4.

Repository - OSU 31390.

Genus PELEKYSGNATHUS Thomas, 1949

Type species Pelekysgnathus inclinatus Thomas, 1949

Pelekysgnathus? sp.

Pl. 2, figs. 5-7

Description - All three I elements are broken. The most complete one has two and one-half pointed, laterally compressed ridge denticles. The two posterior denticles are directed slightly posteriorly. The half denticle, which has been broken, is directed anteriorly. The most posterior denticle is also the largest. The aboral surface is largely broken off, but what remains suggests an excavated surface.

The oistodiform cones are much larger than the drepanodiform cones. Both have cusps that are reclined (the oistodoform cones are very reclined), laterally compressed, and acostate. Both types of cones are bilaterally symmetrical. The basal cavity of the drepanodiform cone is fairly rounded in the aboral view, while that of the oistodiform cone is very laterally compressed.

Remarks - The I element may not belong to Pelekysgnathus Thomas because the largest ridge denticle seems too closely associated with the adjacent ridge denticle to be a cusp. The two types of conodonts are considered possible M_2 and S_2 elements based on Pelekysgnathus inclinatus Thomas in Klapper and Philip (1972).

Occurrence - Sample 3 contains three I elements, four oistodiform elements, and three drepanodiform elements.

Repository - I element, OSU 31397. Oistodiform element, OSU 31395. Drepanodiform element, OSU 31396.

Genus POLYGNATHUS Hinde, 1879

Type species: Polygnathus dubius Hinde, 1879, by subsequent designation, Miller, 1889.

Polygnathus delicatulus Ulrich & Bassler, 1926

Pl. 1, fig. 8. Pl. 2, fig. 2.

Polygnathus delicatulus n. sp. - Ulrich & Bassler, 1926, pl. 7, figs 9, ?10 [reillustrated by Huddle, 1968, pl. 14, figs. 22-24, and 20; reillustrated by Ziegler et al., 1975, Polygnathus pl. 6, figs. 5a, b].

P. delicatula Ulrick & Bassler. - Klapper, 1966, pl. 6, figs. 7, 9, 10.

Remarks - This specimen agrees well with the diagnosis of Klapper (1966), except that it is not "narrow and lanceolate" and the anterolateral margins are not upturned. However, there is good agreement on the delicate transverse ridges on the margins, the nearly straight carina, the nearly symmetrically divided platform, the basal cavity set in the trough separating the transverse ridges from the carina.

Occurrence - One specimen from sample 16.

Repository - OSU 31389.

Polygnathus semicostatus Branson & Mehl, 1934

Pl. 1, figs. 1, 2, 6, 7.

Polygnathus semicostata n. sp. - Branson & Mehl, 1934, pl. 21, figs. 1, 2 [reillustrated by Ziegler et al., 1975, Polygnathus pl. 5, figs. 6a, b].

P. semicostata Branson & Mehl. - Thomas, 1949, pl. 1, fig. 23.

P. sp. A. - Thomas, 1949, pl. 2, figs. 22, 25.

Polygnathus semicostata Branson & Mehl. - Beach, 1961, pl. 5, figs, 9, 10.

P. semicostata Branson & Mehl. - Ethington, 1965, pl. 68, fig. 5.

Remarks - The specimens from samples 16, 17, and 18 agree well with the original description. The only differences are that there are usually 5 or 6 transverse ridges on the posterior oral margin, instead of "about 10"; the posterior part of the plate is consistently pointed; and the carina originates between 1/4 and 1/3 of the way from the posterior end, instead of halfway. Polygnathus linguiformis is characterized by a sharp lateral flexure where the transverse ridges end and the carina begins. Polygnathus obliquicostus is too wide, has too sharp a lateral flexure, and is characterized by diagonal ridges on the inner half of the platform. Polygnathus sanduskiensis is too broad and too sharply flexed, also.

Occurrence - Four specimens were recovered from sample 16, 3 from sample 17, and one from sample 18.

Repository - OSU 31398 is from sample 17, and OSU 31391 is from sample 16.

Polygnathus cf. P. semicostatus Branson & Mehl, 1934

Pl. 1, figs. 4, 5. Pl. 2, fig. 1.

Description - The plate is narrow, and is twice as long as it is wide. It is seen to gently arc laterally in the

oral view. It arcs vertically in the lateral view. The posterior third of the oral surface of the platform has about 5 discontinuous lateral ridges. The carina is faintly visible crossing these ridges. The carina in the anterior part of the plate is slightly lower than the rim, and is composed of welded nodes. The walls descend sharply from the rim, forming a wide, deep, "U-shaped" trough. There are transverse ridges descending partway down into the trough from the nodes on the rim. The walls are rounded and close together at their anterior termination.

In the aboral view the keel is sharp, although it may flatten slightly at the posterior tip. The pit is set in the keel on the anterior part of the plate. The pit is shallow, fairly small, elongate, and attenuate posteriorly. The free blade is preserved on the specimen from sample 3. This is very thin and broken, but it does contain 5 denticles.

Remarks - These two specimens were distinct from those in samples 16, 17 and 18 in two important areas. The carina in these two specimens was lower than the rim in the anterior half of the plate, while in the older specimens the carina was clearly higher than the rim in the anterior half of the plate. Also, the discontinuity of the transverse ridges, combined with the faint continuity of the carina in the two younger specimens contrasts with the older ones.

Occurrence - One specimen each from samples 12 and 3. The figured specimen is from sample 12.

Repository - OSU 31392 is from sample 12.

Polygnathus sp. A

Pl. 1, fig. 8. Pl. 2, fig. 3.

Description - The plate of this P element is nearly straight and bilaterally symmetrical in the oral view. The welded nodes on the rim and on the carina stand out in sharp relief. The rim meets the carina about 1/8 of the length of the carina from its posterior end. This last part of the carina has three small, closely-spaced nodes which stand out in relief. The nodes on the rim continue as transverse ridges down into the inside of the trough. The plate is seen to narrow anteriorly.

In the lateral view the plate arches gently. In the aboral view the pit is shallow, small, and elongate, and is set in the keel. The keel is sharp.

Remarks - The diagnostic feature of this specimen is the early termination of the rim. Thomas (1949) illustrated a similar specimen (pl 3, fig. 33) which he labeled Polygnathus sp. B. They appear to be the same species, and the significance of this was discussed earlier.

Occurrence - One specimen came from sample 3.

Repository - OSU 31393.

Polygnathus sp. B

Pl. 1, fig. 10 and Pl. 2, fig. 4.

Description - This P element is widest in the mid-posterior region, and then tapers sharply posteriorly. The trough has steep walls descending from the rim. Welded nodes

on the rim extend partway into the trough as transverse ridges. The carina is composed of welded nodes. The posterior quarter of the oral side has nodes on both sides of the carina, which joins with the left rim just before the posterior tip. More nodes are present on the right side. In the oral view the plate is nearly straight but asymmetrical, with the carina slightly left of center.

In the lateral view the plate is gently arched. In the aboral view the keel is sharp and the pit is anteriorly located. The pit is small, shallow, and elongate.

Remarks - This was the only specimen of Polygnathus recovered with nodes in the trough on the oral surface.

Occurrence - One specimen from sample 17.

Repository - OSU 31394.

Polygnathus sp. C

Pl. 1, fig. 3.

Description - This was a very small and slender P element. There are two transverse ridges crossing the posterior oral surface. The carina and rim have welded nodes and nodes, respectively.

Remarks - This specimen was found in association with Polygnathus semicostatus, and may be a juvenile of this species, especially considering the transverse ridges.

Occurrence - One specimen from sample 17.

Repository - OSU 31399.

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APPENDIX

Measured Stratigraphic Sections

Locality 1

Description (from top to bottom):	Thickness (in meters)
Cleveland Shale underlain by Chagrin Shale.	28.76
18. Black fissile Cleveland Shale	7.00
17. Grayer Cleveland Shale, capable of being broken down with kerosene (sample 1 was collected here).	0.40
16. Light gray calcareous siltstone with fine laminae. This bed can be located upstream.	0.04
15. Black Cleveland Shale.	0.07
14. Light bluish-gray pyritic siltstone with burrows.	0.08
13. Interbedded light bluish-gray siltstone beds and silty shale beds. Samples 2, 3, and 4 came from here.	4.30
12. Poorly bedded, resistant siltstone.	0.70
11. Light bluish-gray shale with varying silt concentration. Sample 5 came from here.	2.30
10. A 0.28 m. poorly bedded siltstone with pyrite and brachiopods, underlain by 0.50 m. of interbedded siltstone and silty shale. This is a key bed and outcrops prominently.	0.78
9. Light bluish-gray silty shale with thin carbonate layer of variable composition. Sample 6 came from here.	1.10

8. A thin siltstone with carbonate cement. 0.10

7. Shale with less silt content than above. Sample 7 came from here. 2.10

6. Burrowed and crossbedded siltstone and shale. 0.30

5. Light bluish-gray and lead gray shale. Sample 8 came from here. 1.30

4. Burrowed siltstone. 0.14

3. Soft light bluish-gray and lead gray shale. Sample 9 came from here. 3.00

2. Siltstone with vertical burrows. Sample 10 was from just below this. 0.15

1. Soft light bluish-gray shale with an interval of lead gray shale. Sample 11 was from near the base of this. 5.00

Locality 2

Description (from top to bottom): thickness (in meters)

Chagrin Shale, beginning with the key bed that was item 10 at Locality 1 and moving down through the section. 32.75

16. A thick poorly-bedded siltstone with brachiopods caps, interbedded siltstones and silty shales. 0.70

15. Light bluish-gray silty shale. 3.30

14. Two poorly-bedded, vertically burrowed siltstones with a thin shale layer between them. 0.30

13. Light bluish-gray and lead gray shale. Sample 12 was collected here. 1.40

12. Vertically burrowed siltstone with a reddish-orange stain. 0.35

11. Light bluish-gray, lead gray, and maroon-gray shales with a 0.06 m. siltstone 0.70 m. below the previous unit. 2.90

10. Poorly-bedded siltstone. 0.30

9. Light bluish-gray shale. 4.70

8. Light bluish-gray and maroon-gray silty shale. 2.25

7. Siltstone with high clay content. 0.25

6. Interbedded silty shale and shale. 5.75

5. Burrowed siltstone with carbonate cement. Sample 13 was collected just below this. 0.05

4. Light bluish-gray shale. 7.80

3. Siltstone with high clay content. 0.17

2. Shale. 1.95

1. Interbedded shale and siltstone. 0.50

Locality 3

Description (from top to bottom): Thickness (in meters)

Chagrin Shale. 9.00

4. Same as bottom 4.1 m. at Locality 2. . . . . 4.10

3. Light bluish-gray shale. 3.10

2. Poorly-bedded siltstone with brachiopods in it. This bed is a key bed downstream. 0.28

1. Light bluish-gray shale which contains abundant brachiopods on some layers. Sample 14 was collected 0.40 m. below the key bed. 1.32

Locality 4

Description (from top to bottom):	thickness (in meters)
Chagrin Shale.	.16.31
14. The key bed of Locality 3, a poorly-bedded, resistant siltstone.	0.40
13. Covered interval.	.6.20
12. Poorly-bedded, resistant siltstone. This bed and the next 4 siltstone beds as a unit served as a key interval.	.0.30
11. Soft bluish-gray shale.	.1.30
10. Poorly-bedded, resistant siltstone.	0.38
9. Same as 11.	.1.25
8. A less resistant, poorly-bedded siltstone.	.0.15
7. Same as 11.	.1.40
6. A less resistant siltstone.	.0.10
5. Same as 11.	.2.60
4. Siltstone bed.	0.25
3. Same as 11..	.0.32
2. Less resistant siltstone.	.0.06
1. Same as 11.	.1.60

Locality 5

Description (from top to bottom)	Thickness (in meters)
Chagrin Shale.	.35.48

26. Poorly-bedded siltstone. 0.15

25. Soft, light bluish-gray shale. 1.00

24. Very silty shale. 0.10

23. Same as 25. . . . . .0.50

22. Poorly-bedded, resistant siltstone. 0.40

21. Same as 25. . . . . .4.05

20. Poorly-bedded, resistant siltstone. 0.15

19. Interbedded thin siltstones and shale (dominantly shale). 9.30

18. Thin, poorly-bedded, siltstone. 0.10

17. Same as 19. . . . . .3.25

16. Very resistant, poorly-bedded siltstone. The key bed of Locality 3. . . . . 0.40

15. Same as 19. . . . . .4.33

14. Thin, resistant siltstone. 0.03

13. Same as 19. . . . . .1.20

12. Poorly-bedded siltstone. 0.10

11. Shale with brachiopods. 0.34

10. Resistant, poorly-bedded siltstone. This begins the key beds at Locality 4. . . . . 0.24

9. Light bluish-gray shale with thin beds of carbonate which are stained pink because of the presence of siderite. 1.50

8. Poorly-bedded, resistant siltstone. 0.34

7. Same as 25. . . . . .1.30

6. Same as 8... . . . . 0.15

5. Same as 25. . . . . .1.30

4. Same as 8. . . . . 0.20

3. Same as 9. . . . . 3.00

2. Same as 8. This is the last of a series of key beds from Locality 4. . . . . .0.25

1. Same as 9. . . . . 1.80

Locality 6

Description (from top to bottom): thickness (in meters)

Chagrin Shale. 28.26

15. Thick, poorly-bedded, resistant siltstone. 0.42

14. Soft light bluish-gray shale. 1.30

13. Covered interval. 6.65

12. Same as 15. This is interpreted as the second key bed of the series of key beds from Locality 4. . . . . .0.34

11. Shale, same as 14. . . . . 1.35

10. Siltstone, same as 15. . . . . 0.15

9. Shale, same as 14. . . . . 1.25

8. Siltstone, same as 15. . . . . 0.20

7. Light bluish-gray shale with variable silt content. 3.00

6. Siltstone, same as 15. This is interpreted as the lowest of the key beds of Locality 4. . . . . 0.30

5. Shale, same as 14. . . . . 2.80

4. Siltstone, same as 15. . . . . 0.10

3. Light bluish-gray interbedded non-resistant siltstone and soft shale. 6.00

2. Siltstone that is less resistant than 15, and more like the surrounding shale. 0.25

1. Light bluish-gray shaly siltstone, silty shale, and soft shale. Brachiopods were found in a silty bed 1.0 m. from the bottom, and Sample 15 was collected here. 4.15

Locality 7

Description (from top to bottom): thickness (in meters)

Chagrin Shale. 28.40

28. Two thick, poorly bedded, resistant siltstone beds separated by a thin bed of shale. Together these represent the key bed of Locality 3. . . . . 0.40

27. Soft bluish-gray shale. 5.05

26. Thick, poorly-bedded, resistant siltstone. This represents the first of the series of key beds at Locality 4. . . . . 0.30

25. Shale, same as 27. . . . . 1.45

24. Siltstone, same as 26. . . . . 0.20

23. Shale, same as 27. . . . . 1.50

22. Siltstone, same as 26. . . . . 0.25

21. Shale, same as 27. . . . . 2.65

20. Siltstone, same as 26. This represents the last of the key beds at Locality 4. . . . . .0.40

19. Silty shale. 0.45

18. Siltstone, same as 26. . . . . 0.10

17. Shale, same as 27. . . . . 1.40

16. A less resistant shaly siltstone. 0.17

15. Shale, same as 27. . . . . 0.50

14. Shaly siltstone. 0.13

13. Interbedded silty shale and shale. 1.00

12. Siltstone, same as 26. . . . . 0.20

11. Shale with a low silt content. 1.70

10. Interbedded shale, silty shale and shaly siltstone. 1.00

9. Shaly siltstone. 0.20

8. Soft bluish-gray shale. 0.50

7. Interbedded shaly siltstone and shale. 1.80

6. Interbedded silty shale and soft shale. 1.85

5. Interbedded shaly siltstones and silty shales. 1.00

4. Soft, less resistant shale. 1.90

3. Lead gray, more fissile, more resistant shale. 0.60

2. Soft bluish-gray shale with a yellowish surface. 0.10

1. Soft bluish-gray shale, Sample 16 came from the top of this interval and sample 17 came from the bottom. 0.60

Locality 8

Description (from top to bottom): thickness (in meters)

Chagrin Shale. 52.08

38. Poorly-bedded, resistant siltstone. This is the first key bed of Locality 4. . . . . .0.34

37. Soft bluish-gray shale. 1.50

36. Siltstone, same as 38. . . . . 0.25

35. Shale, same as 37. . . . . 1.50

34. Siltstone, same as 38. . . . . 0.28

33. Shale, same as 37. . . . . 2.50

32. Siltstone, same as 38. . . . . 0.30

31. Shale, same as 37. . . . . 1.30

30. Silty shale. 1.50

29. Siltstone, same as 38. . . . . 0.18

28. Shale. 0.70

27. Shaly siltstone. 0.10

26. Interbedded silty shale and soft shale. 7.30

25. More resistant silty shale. 0.70

24. Shale, same as 37. . . . . 2.50

23. Covered interval. 3.85

22. Siltstone with better bedding than 38. . . . . 0.35

21. Shale, same as 37. . . . . 1.00

20. Shaly siltstone with fine laminae that split easily along bedding planes. Contains sparse coalified plant remains. Very resistant. 0.50

19. Shale with decreasing silt content downward. 2.20

18. Less resistant shaly siltstone. 0.14

17. Shale, same as 37. . . . . .2.00

16. Moderately resistant siltstone. 0.30

15. Shale, same as 37. . . . . 3.40

14. Less resistant, shaly siltstone. 0.16

13. Shale. 0.40

12. Siltstone, same as 14. . . . . 0.13

11. Shale. 0.60

10. Siltstone, same as 20. . . . . 0.60

9. Shale with high silt content. 3.60

8. Siltstone, same as 20. . . . . 0.50

7. Shale. 1.30

6. Siltstone, same as 20. . . . . 0.10

5. Shale with low to moderate silt content. 2.50

4. Very prominent siltstone as in 20; the borders of it are hard to distinguish. Central part is very resistant. 1.00

3. Shale with high silt content at top, lower silt content below. 3.80

2. Siltstone, as in 20. . . . . 0.40

1. Shale with variable silt content; sample 18 was collected 1.0 m. below unit 2. . . . . .2.30

TABLE 1

SAMPLE DESCRIPTIONS

Sample #	Locality Collected At	Distance Below Chagrin and Cleveland Shale Contact (m.)	Distance Below Top of Section	Original Sample wt. (kg.)	Wt. of Sample Reduced
1	1	-0.30	7.21	4.40	2.90
2	1	0.35	7.86	1.50	0.95
3	1	2.00	9.51	1.60	1.10
4	1	2.20	9.71	3.40	1.80
5	1	6.50	14.01	1.85	0.50
6	1	8.40	15.91	0.95	0.45
7	1	10.25	17.76	0.95	0.40
8	1	11.60	19.11	2.00	0.65
9	1	13.35	20.86	1.10	0.70
10	1	16.50	24.01	1.30	1.00
11	1	20.20	27.71	1.50	0.95
12	2	12.50	5.70	1.30	0.70
13	2	29.30	22.50	0.90	6.85
14	3	43.20	7.88	1.90	1.00
15	6	68.20	27.26	0.94	0.35
16	7	71.60	27.90	2.20	1.80
17	7	72.10	28.30	2.40	2.35
18	8	100.90	51.98	1.65	1.45

TABLE 1 (continued)

SAMPLE DESCRIPTIONS

Sample #	# of Conodonts (whole and fragmentary)	A_1, A_2, A_3 Elements (after Klapper & Philip, 1972)	B_1, B_2, B_3 Elements	Ozarkinodina
1	7	1	0	0
2	0	0	0	0
3	71	27	1	1
4	3	2	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	3	1	0	0
9	2	2	0	0
10	1	0	0	0
11	5	1	0	0
12	8	5	0	0
13	9	4	0	0
14	5	3	0	0
15	6	2	0	0
16	60	31	2	0
17	239	74	8	0
18	11	6	0	0

TABLE 1 (continued)

SAMPLE DESCRIPTIONS

Sample #	Bryantodus	Spatho-gnathodus	Poly-gnathus	Simple Cones
1	0	4	0	0
2	0	0	0	0
3	2	4	2	7
4	0	0	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	1	0	1
9	0	0	0	0
10	0	0	0	1
11	0	0	1	3
12	0	1	0	0
13	0	1	0	0
14	0	1	0	1
15	0	0	1	1
16	3	1	8	0
17	16	28	17	3
18	1	0	18	1

TABLE 1 (continued)

SAMPLE DESCRIPTIONS

Sample #	Pelekysgnathus (I element)	Icriodus (I element)	N elements	Unidentified
1	0	0	0	2
2	0	0	0	0
3	1	0	0	26
4	0	1	0	0
5	0	0	0	0
6	0	0	0	0
7	0	0	0	0
8	0	0	0	0
9	0	0	0	0
10	0	0	0	0
11	0	0	0	0
12	0	0	0	2
13	0	0	0	4
14	0	0	0	0
15	0	0	0	2
16	0	0	0	15
17	0	0	8	0
18	0	0	0	3

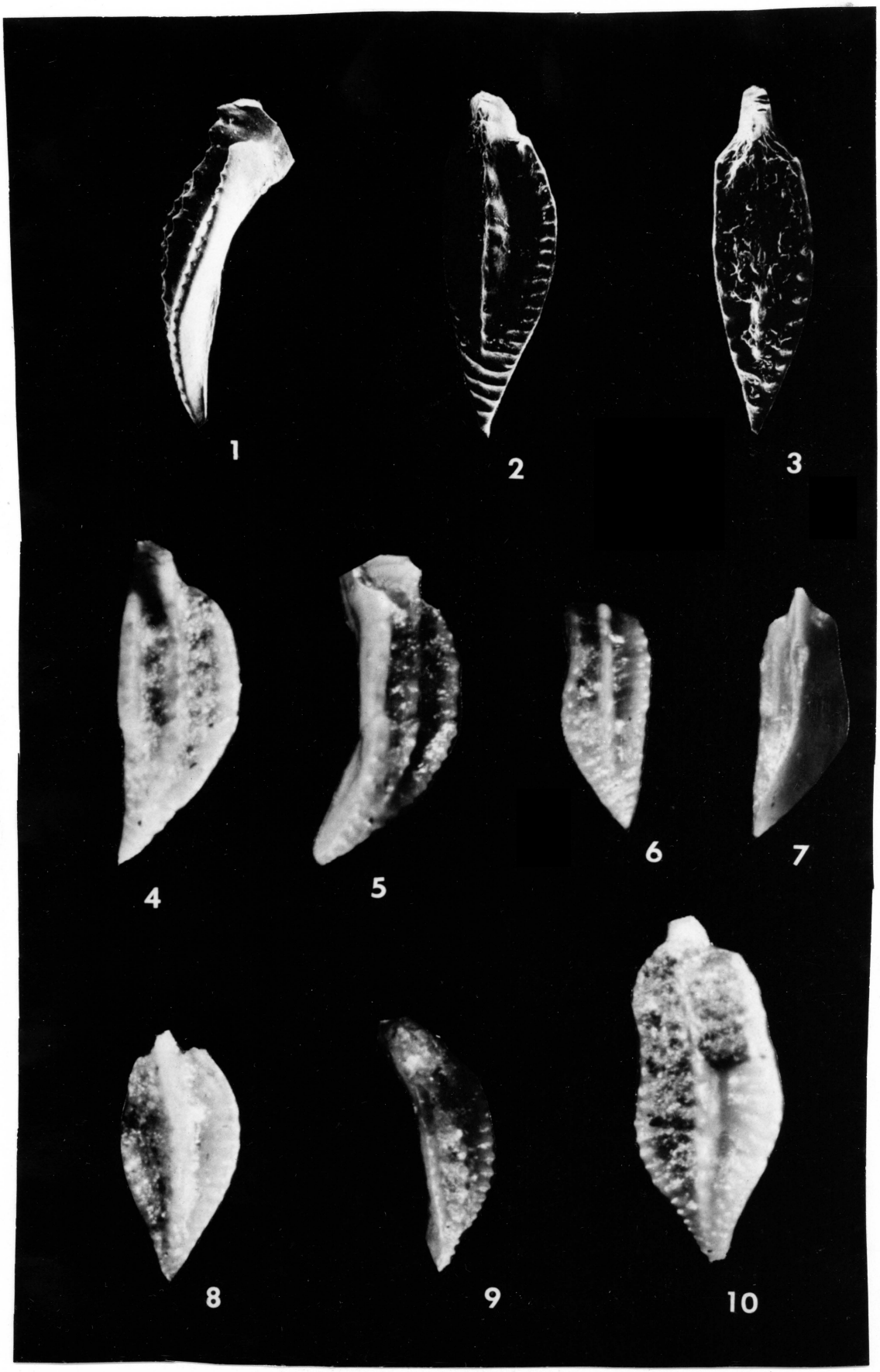
EXPLANATION OF PLATE 1

Figure 1 is x57; 2, x60; 6, x114; 3-5 and 7-10, x49.

Figures

1, 2, 6, 7	Polygnathus semicostatus Branson and Mehl. 1, 2, lateral and oral views of OSU 31398; sample 17. 6, 7, oral and aboral views of OSU 31391, sample 16.
3	Polygnathus sp. C. Oral view of OSU 31399, sample 17.
4, 5	Polygnathus cf. P. semicostatus (Branson and Mehl). Oral and oblique views of OSU 31392, sample 12.
8	Polygnathus delicatulus Ulrich and Bassler. Oral view of OSU 31389, sample 16.
9	Polygnathus sp. A. Oral view of OSU 31393, sample 3.
10	Polygnathus sp. B. Oral view of OSU 31394, sample 17.

PLATE 1



EXPLANATION OF PLATE 2

Figures 1-4 are x52, and 5-7 are x87.

Figures

1 — Polygnathus cf. P. semicostatus (Branson and Mehl). Aboral view of OSU 31392, sample 12.

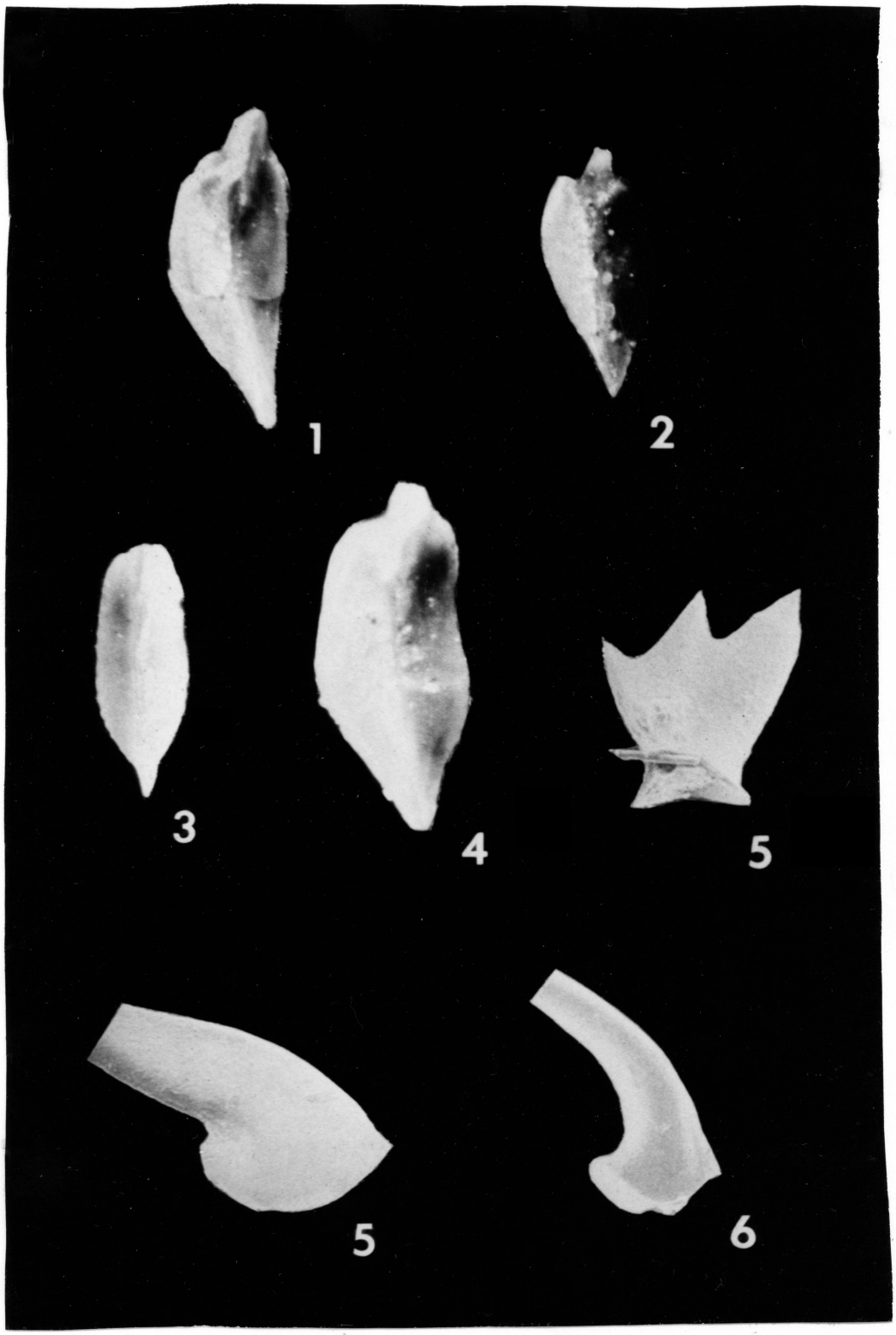
2 — Polygnathus delicatulus Ulrich and Bassler. Aboral view of OSU 31389, sample 16.

3 — Polygnathus sp. A. Aboral view of OSU 31393, sample 3.

4 — Polygnathus sp. B. Aboral view of OSU 31394, sample 17.

5-7 — Pelekysgnathus? sp. 5, lateral view of oistodiform element, OSU 31395, sample 3; 6, lateral view of drepanodiform element, OSU 31396, sample 3; 7, lateral and slightly oral view of the I element, OSU 31397, sample 3.

PLATE 2



EXPLANATION OF PLATE 3

Figures

1, 2 — *Icriodus* sp. 1, lateral view, OSU 31390, sample 4; 2, aboral view of same specimen. Both are x55.

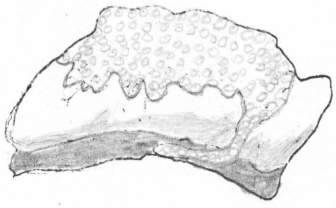


PLATE 3